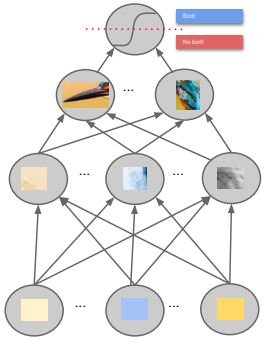
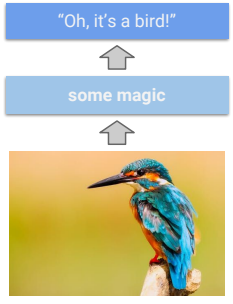
Deep Learning

Introduction

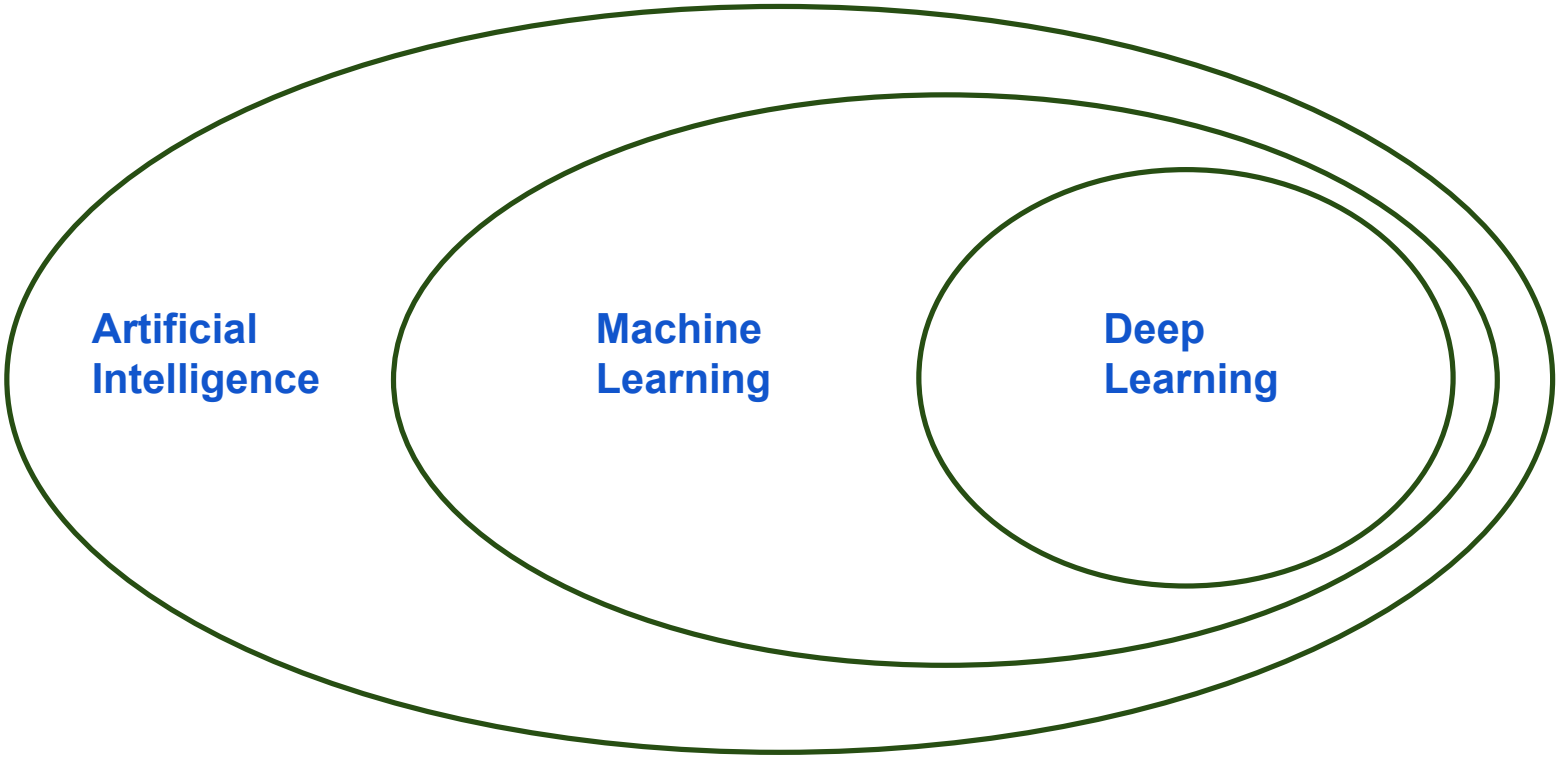




Learning goals

- Relationship of DL and ML
- Concept of representation or feature learning
- Use-cases and data types for DL methods

WHAT IS DEEP LEARNING



- Deep learning is a subield of ML based on artificial neural networks.

DEEP LEARNING AND NEURAL NETWORKS

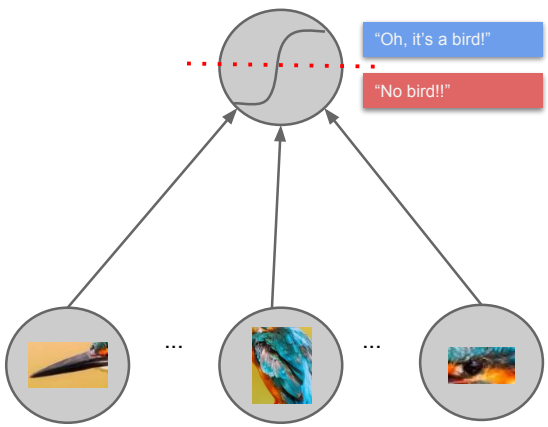
- Deep learning itself is not *new*:
  - Neural networks have been around since the 70s.
  - *Deep* neural networks, i.e., networks with multiple hidden layers, are not much younger.

- Why everybody is talking about deep learning now:
  1. Specialized, powerful hardware allows training of huge neural networks to push the state-of-the-art on difficult problems.
  2. Large amount of data is available.
  3. Special network architectures for image/text data.
  4. Better optimization and regularization strategies.

IMAGE CLASSIFICATION WITH NEURAL NETWORKS

“Machine learning algorithms, inspired by the brain, based on learning multiple levels of representation/abstraction.”

Y. Bengio



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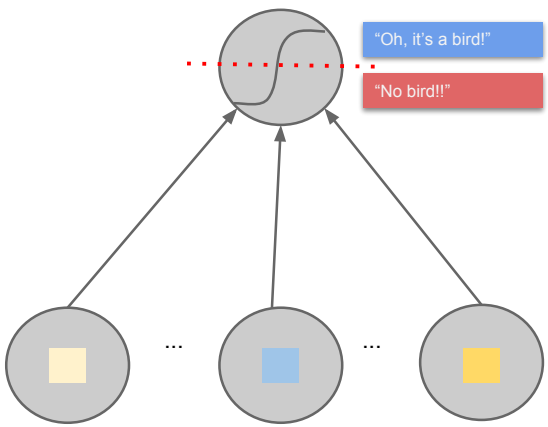

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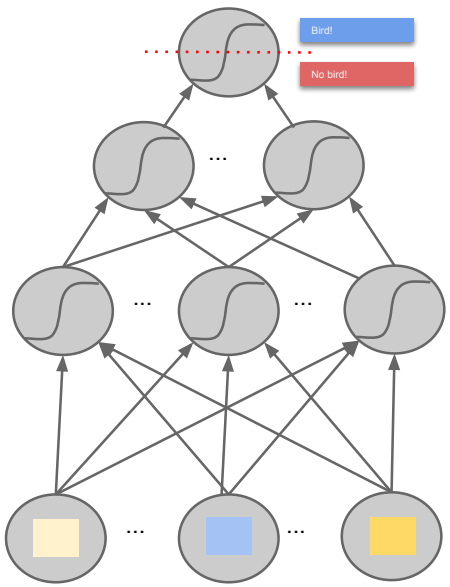

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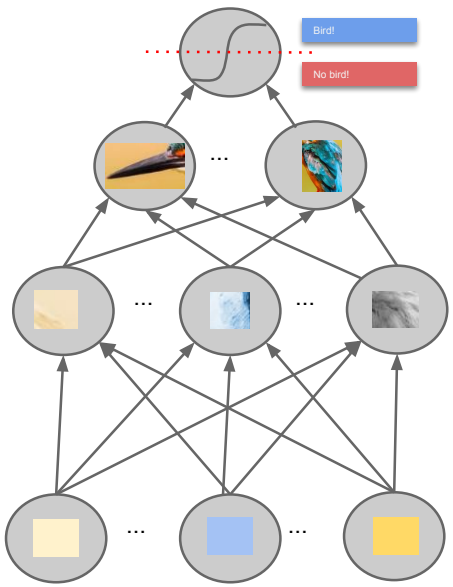


POSSIBLE USE-CASES

Deep learning can be extremely valuable if the data has these properties:

- It is high dimensional.
- Each single feature itself is not very informative but only a combination of them might be.
- There is a large amount of training data.

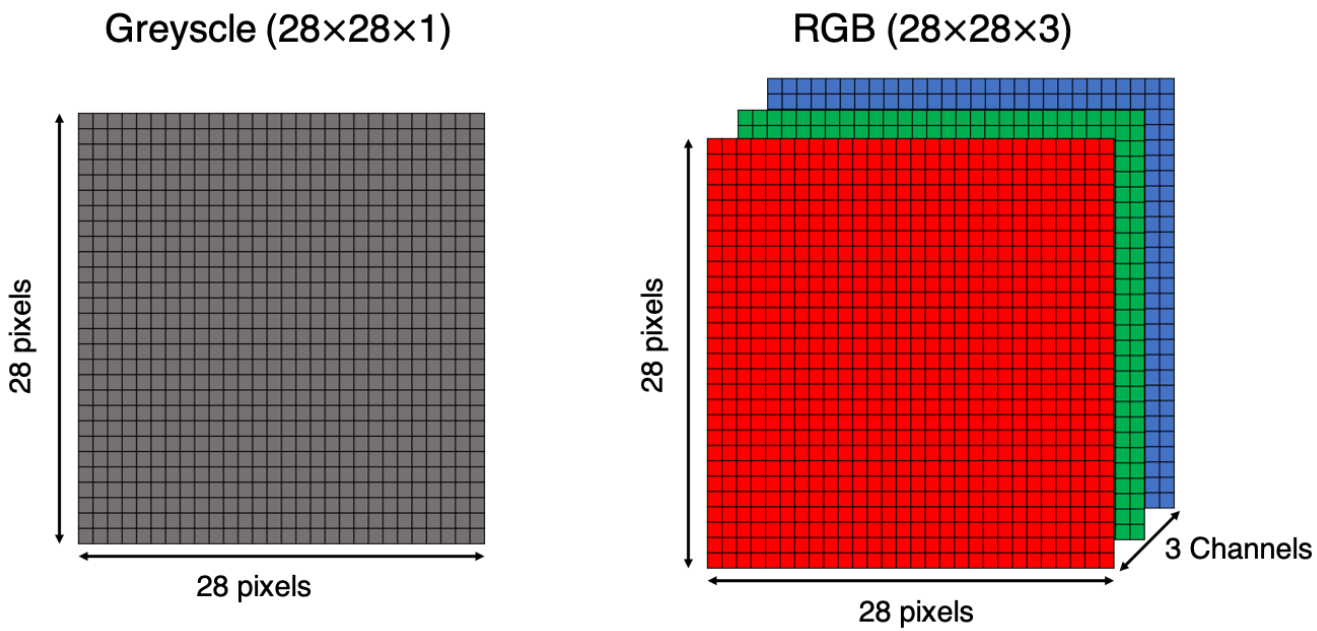
This implies that for tabular data, deep learning is rarely the correct model choice.

- Without extensive tuning, models like random forests or gradient boosting will outperform deep learning most of the time.
- One exception is data with categorical features with many levels.

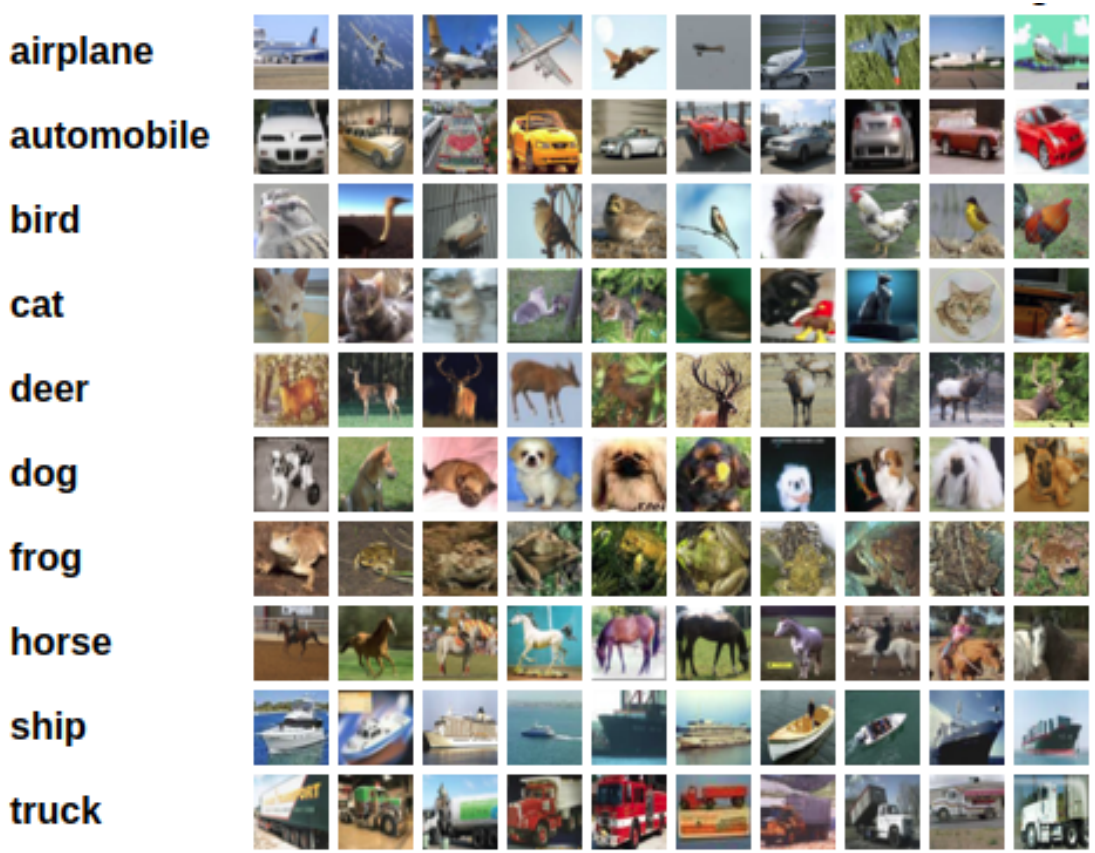
POSSIBLE USE-CASE: IMAGES

- **High Dimensional**: A color image with 255×255 (3 Colors) pixels already has 195075 features.
- **Informative**: A single pixel is not meaningful in itself.
- **Training Data**: Depending on applications huge amounts of data are available.

Architecture: **C**onvolutional **N**eural **N**etworks (CNN)



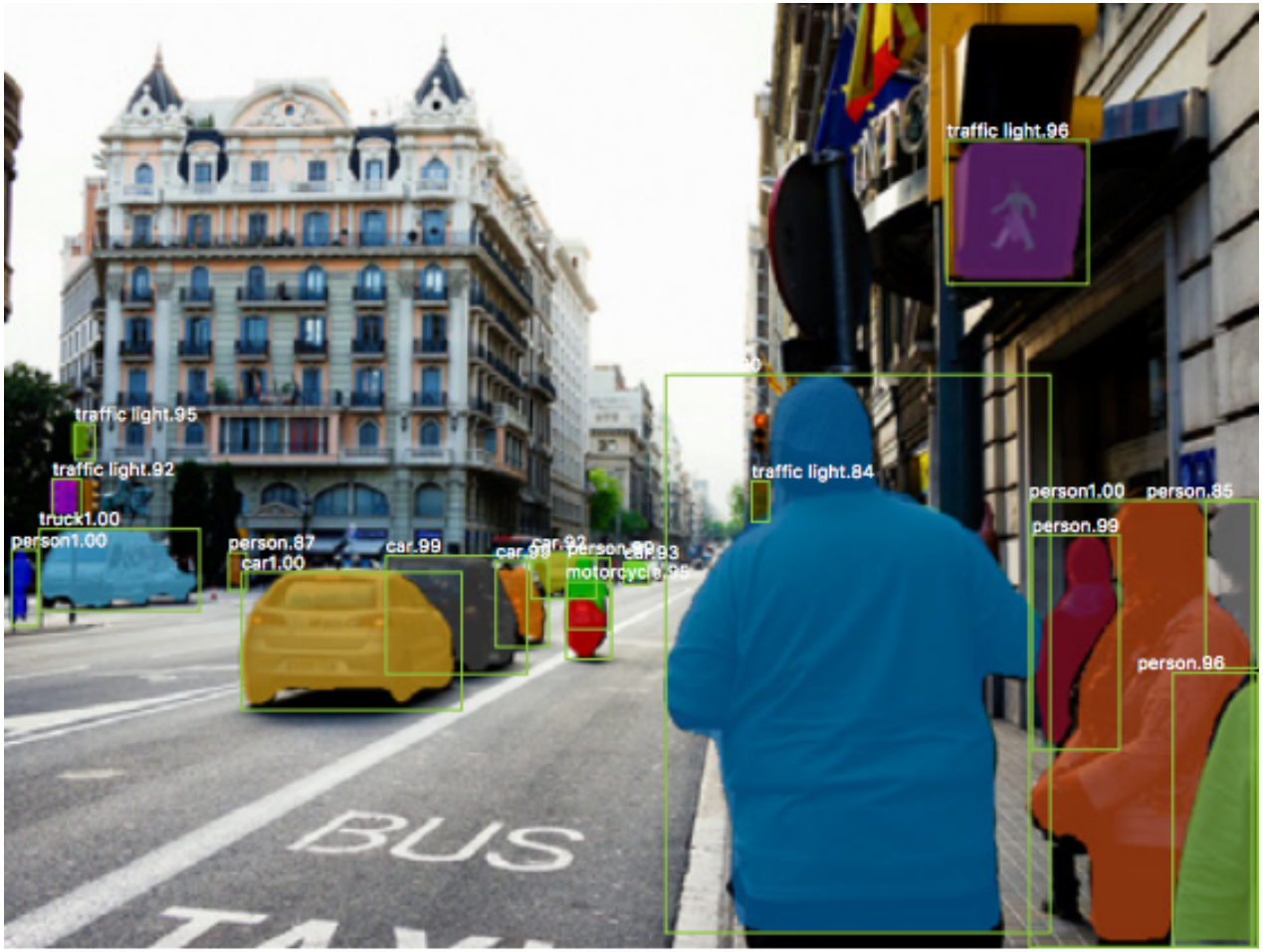
POSSIBLE USE-CASE: IMAGES



Credit: Alex Krizhevsky (2009)

Image classification tries to predict a single label for each image.
CIFAR-10 is a well-known dataset used for image classification. It consists of 60, 000 32*x*32 color images containing one of 10 object classes, with 6000 images per class.

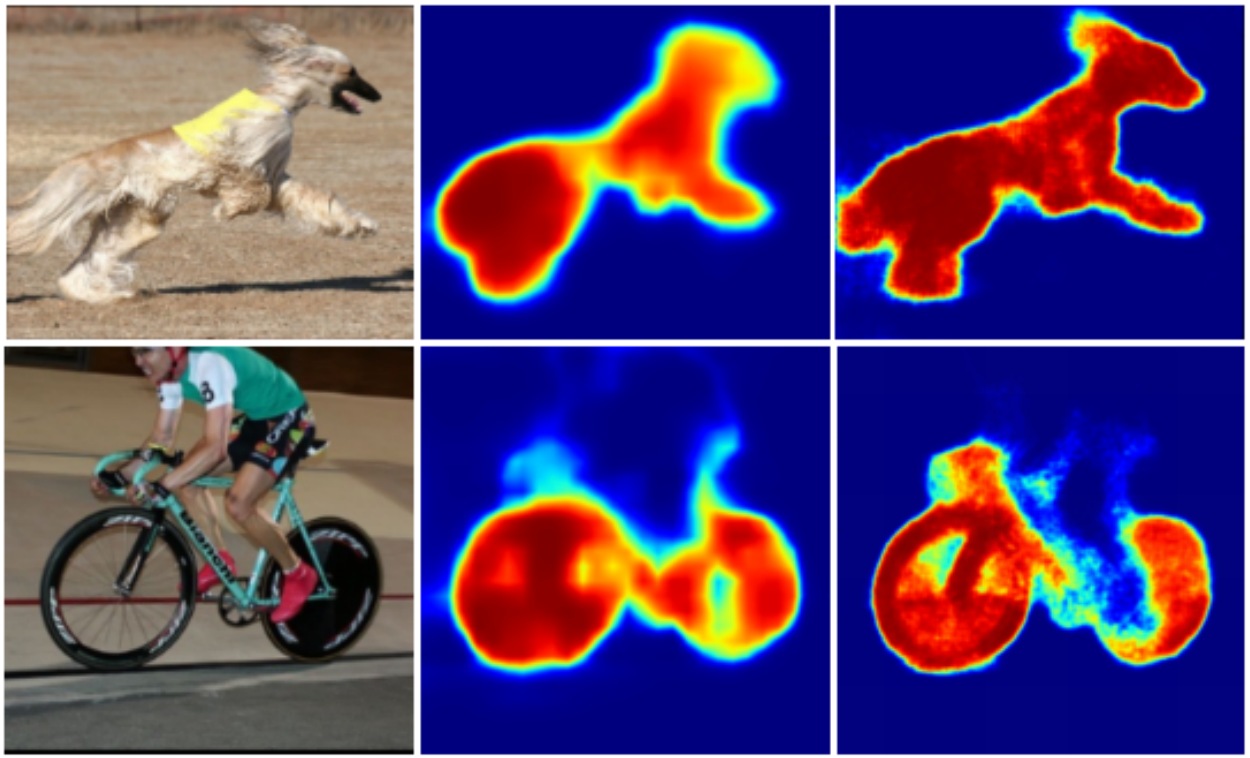
POSSIBLE USE-CASE: IMAGES



Credit: Kaiming He (2017)

Object Detection Mask R-CNN is a general framework for instance segmentation, that efficiently detects objects in an image while simultaneously generating a high-quality segmentation mask for each instance.

POSSIBLE USE-CASE: IMAGES



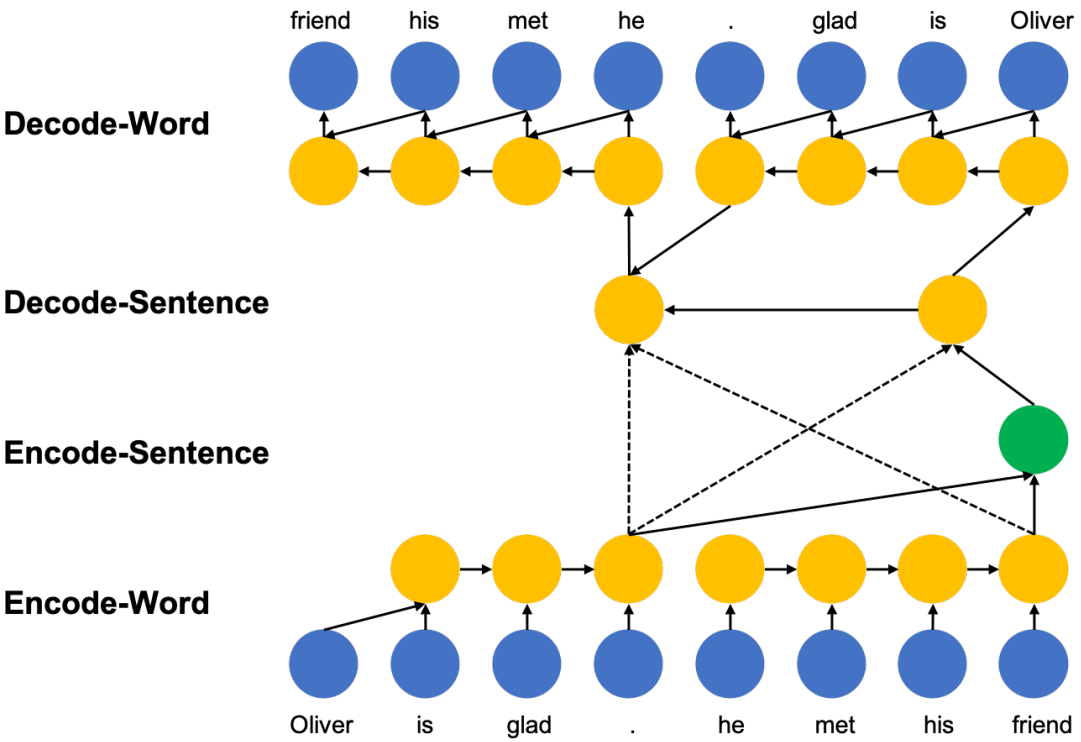
Credit: Hyeonwoo Noh (2015)

Image segmentation partitions the image into (multiple) segments.

POSSIBLE USE-CASE: TEXT

- **High Dimensional**: Each word can be a single feature (300000 words in the German language).
- **Informative**: A single word does not provide much context.
- **Training Data**: Huge amounts of text data available.

Architecture: **R**ecurrent **N**eural **N**etworks (RNN)



POSSIBLE USE-CASE: TEXT CLASSIFICATION

Positive

Great job! Your customer support is fantastic.

Neutral

Not bad, but it should be improved in the future.

Negative

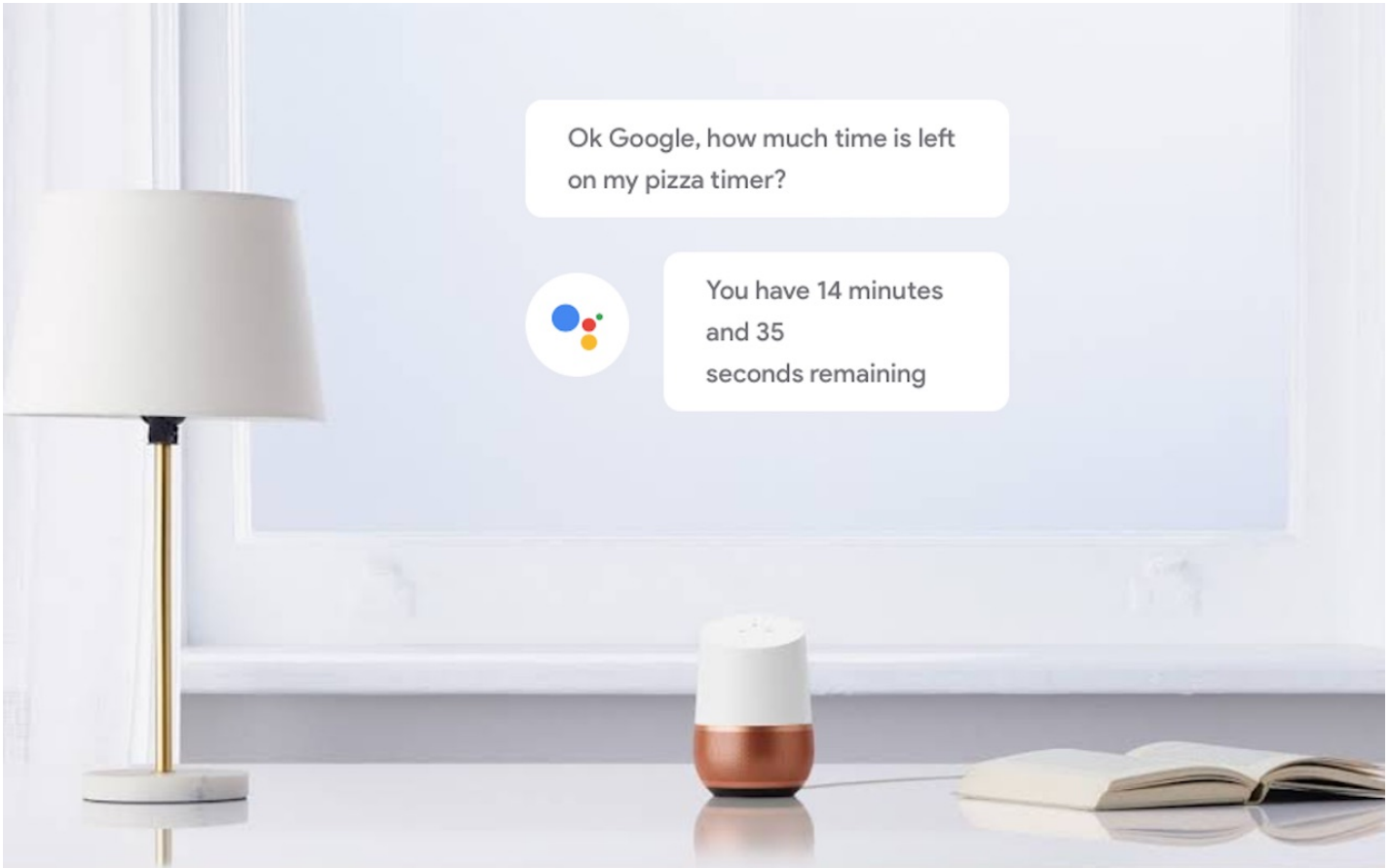
The worst customer service I have ever seen.

Sentiment Analysis is the application of natural language processing to systematically identify the emotional and subjective information in texts.

POSSIBLE USE-CASE: TEXT

Machine Translation (e.g. google translate) Neural machine translation exploits neural networks to predict the likelihood of a sequence of words, typically modeling entire sentences in a single integrated model.

APPLICATIONS OF DEEP LEARNING: SPEECH



Speech Recognition and Generation (e.g. google assistant) Neural network extracts features from audio data for downstream tasks, e.g., to classify emotions in speech.